A TRANSPORTABLE MODULAR BUILDING AND A METHOD OF CONSTRUCTING THEREOF

[001] The present invention relates to a method of constructing a transportable modular building and to a transportable modular building constructed according to this method.

[002] Typical apartment and apartment-office buildings are usually constructed on a building site in a sequence of separate technological operations. These operations are most often carried out by different workers having suitable skills, and the building duration usually lasts from about several months to several years and is dependent, among other factors, on the weather conditions. All these conditions influence the total cost of the building.

[003] There are many well-known techniques in the building industry addressing the issue of reducing the building expenses, such as preliminary construction of entire buildings, or their walls or modules out of the building parcel, and subsequent transportation thereof to the building site. The reduction of expenses is achieved mostly by means of large-scale production of such units and reducing a number of assembly operations at the building site.

[004] U.S. Patent 4,501,098 describes a method of constructing a house comprising the steps of constructing modular structures for a first level of the house away form the building site in a factory. The modular structures are positioned in end to end aligned relation to facilitate transportation and substantially define all standard dimensions of the first level of the house. After delivery to the building site, the modular structures are separated and positioned on the foundation, and remaining elements of the first level and the second level if there is one, are then constructed to provide those portions of the house possessing appropriate architectural design. Finally a roof structure is constructed over the house and exterior finishing is performed.

[005] Other constructions of modular buildings are disclosed among others in U.S. Patents 3,862,534 and 3,492,767.

[006] The aim of the present invention is to provide a method of constructing a transportable modular building, which would allow fast and inexpensive assembly of the building on the building site, would be functional and easy to transport.

[007] According to the present invention there is provided a method of constructing of a transportable modular building, comprising the step of making the foundation at the building site, which further comprises the steps of: (a) producing in a factory, out of the building site, at least one service module of a frame construction, which enables a container transportation thereof and is advantageously provided with appropriate building installations, where its height substantially corresponds to half of its length; (b) producing in a factory, out of the building site, at least two horizontal segments of a frame construction having the width substantially corresponding to the height of the service module and the length substantially corresponding to the length of the service module, and at least one vertical segment of a frame construction having the height substantially corresponding to the height of the service module the length substantially corresponding to the length of the service module; (c) transportation of the service modules, the horizontal and vertical segments to the building site by means of a vehicle apt to container transportation; (d) attaching the service modules on the foundation of the building; (e) attaching a suitable number of the horizontal segments on the foundation of the building and connecting them with the service module at the level of the bottom plate of the service module; (f) attaching an appropriate number of the vertical segments to the horizontal segments; and (g) attaching an appropriate number of the horizontal segments to the vertical segments and to the service module at the level of the top plate of the service module.

[008] The term "the height of the service module", as used herein, means external as well as internal height thereof, in the dependence of the selected method of assembling the building.

[009] The term "vehicle apt to container transportation", when used above and below, refers to a vehicle adapted to transport containers, in particular two standardized 20 ft (length 6.1 m x width 2.4 m) containers or one 40 ft

(length 12.2 m x width 2.4 m) or 40 ft HC (length 12.2 m x width 2.4 m) container, and preferably provided with means necessary for this type of transport, such as anchors and/or hooks.

[010] Thanks to producing elements of the building out of the building site, considerable savings are achieved, arising mostly with employing the virtues of a large-scale production, initial equipment of the service module with suitable installations, the simplicity and short assembly time (low cost of labor). The outline of the horizontal and vertical elements does not exceed the outline of the walls of the service module, and thus it is possible to group the elements side by side and to load them on one truck along with the service module. Furthermore, the building after assembling may be easily decomposed and transported again. Employing the elements of a similar construction and similar dimensions greatly lowers the building production and assembling costs.

[011] During transportation the horizontal and vertical segments of the building may easily stacked and temporarily connected together, to form a block having length and width corresponding to length and width of a standardized container. On the other hand the horizontal outline of the service module preferably corresponds to the horizontal outline of the container. The above features facilitate transport of the building.

[012] It is particularly advantageous if the horizontal segments are attached to the service module perpendicularly to the longitudinal axis thereof.

[013] At least two service modules may be advantageously connected in end to end aligned relation with each other on the same level.

[014] "End to end aligned relation" means that corresponding walls of the adjoined service modules are positioned on the same plane.

[015] The method may also advantageously comprise the additional step of connecting of at least two service modules parallel one on another. It allows to construct a multi-storeyed building.

[016] It is also preferable to provide said segments of the building with appropriate door and window openings and/or appropriate building installations while producing them in the factory out of the building site. Similarly in the case of the service module, this operation lowers the total cost of the building.

[017] After finishing of the building assembly it is advantageous to provide such a constructed building with additional rafter framing, balconies and/or other structural elements.

[018] According to the present invention there is also provided a transportable modular building comprising at least one service module of a frame construction, which enables container transportation thereof and is advantageously provided with appropriate building installations, where its height substantially corresponds to half of its length, at least two horizontal segments of a frame construction having the width substantially corresponding to the height of the service module and the length substantially corresponding to the length of the service module, at least one vertical segment of a frame construction, having the height substantially corresponding to the height of the service module and the length substantially corresponding to the length of the service module, wherein after assembling the building at the building site, the horizontal segments are attached to the foundation of the building on the level of the bottom plate of the service module or on the level of the top plate of the service module and to the vertical segments, and the vertical segments are attached to the horizontal segments.

[019] The dimensions of particular elements may be slightly different, in dependence on the selected method of assembly and dimensions of the building.

[020] In particularly, the width of the horizontal segments may substantially correspond to the internal height of the service module. In the case of connecting the service modules in end to end aligned relation (as mentioned above), the horizontal segment may overlap two adjoining service modules, which provides greater stiffness of the modular building.

[021] It is also advantageous to employ vertical assembly posts of a square cross-section and the width substantially corresponding to the thickness of the vertical

segment, and place them between adjoining vertical segments. The posts facilitate assembling of building elements and suppress thermal bridges in the corners of the building. Said posts can be made for example from the OSB (oriented standard board) plate warmed with a rock wool.

[022] Preferably the horizontal and vertical segments are of the same construction.

[023] Additionally it is also advantageous if the horizontal vertical segments are of the same dimensions.

[024] The service module and particular building segments are preferably of frame construction closed with OSB plates and filled with rock wool. Other solutions are also possible, for example a steel frame construction closed with corrugated plates or, as in the preceding case, with OSB plates, or Fermacell plates made by Fels-Werke GmbH, Germany.

[025] It is also advantageous if the service module, the horizontal and vertical segments are provided with appropriate means for connecting them together, e.g. bolts that are blocked in corresponding assembly openings.

[026] Alternatively, it is possible to connect said segments, e.g. by welding appropriate steel connectors of adjoining elements.

[027] In the case of employing the segments of similar construction and dimensions, corresponding connectors are placed in the same points of each segment.

[028] In particular, the present invention relates to a modular building which according to the present invention comprises two service modules, which after assembling the building, are connected in end to end aligned relation with each other on the same level, eight horizontal segments constituting the floor of the building, and eight horizontal segments constituting the roof of the building, which are attached to the side walls of the service modules on the level of the floors and the ceilings of the service modules, and eight vertical segments attached to the horizontal segments.

[029] The transportable modular building according to the present invention is visually attractive, functional and enables the formation of a huge number of configurations of particular elements. It is also enables further development, as well as decomposition and subsequent transportation.

[030] The transportable modular building according to the present invention, is shown in exemplary embodiments with reference to the drawings, of which

[031] fig. 1 shows the first embodiment of the present invention before assembling thereof at the building site,

[032] fig. 2 shows a modular building according to the first embodiment during assembling at the building site,

[033] fig. 3 shows another embodiment of a modular building according to the present invention,

[034] fig. 4 shows yet another embodiment of two-floored modular building according to the present invention,

[035] fig. 5 shows an example embodiment of a horizontal segment, and

[036] fig. 6 shows yet another embodiment of modular building during assembling at the building site.

[037] Fig. 1 schematically shows elements of transportable modular building 1 after transportation to the building site, provided earlier with reinforced concrete foundation 5. A single truck apt to container transportation was loaded with all components of the building elements, produced in the factory out of the building site: a service module 2, four horizontal segments 3 and three vertical segments 4. All building elements are of wooden frame construction closed with OSB plates and filled with thermal insulation made of rock wool, and their thickness amounts to 0.25 m. Width of the service module 2 amounts to 2.4 m, height H amounts to 3 m, and length L is two times greater than height H thereof and amounts to 6 m. In this embodiment the dimensions of the horizontal 3 and vertical 4 segments are the same: height (width) corresponds to height H of the service module 2, and

length corresponds to length L of the service module (see Fig. 2). The service module 2, the horizontal segments 3 and the vertical segments 4 are provided with appropriate means in the form of bolts and corresponding assembly openings (not shown) that allow for connecting them together.

[038] Fig. 2 presents a modular building 1, the elements of which were shown in Fig. 1, during the assembly process at the building site. The building shall form a small restaurant. The main unit of the building 1 is the service module 2, which was initially provided with necessary electrical installation, water supply and sewerage system. The module comprises also devices and equipment necessary for the intended function of the building. The service module 2 was mounted on the foundation 5 by means of a crane. Subsequently two floor horizontal segments 3, were placed on the foundation 5 and attached to the floor of the service module 2, perpendicular to the longitudinal axis thereof. In the next step, to the floor horizontal segments 3, on its external side, two perpendicular vertical segments 4 were attached, to which in turn further horizontal segment 3 was attached, constituting the roof of the part of the building 1 outside the service module 2. Two assembly posts 6 of square cross section and the width equal to the width of the vertical segment 4 were attached between adjoining and perpendicular vertical segments 4.

[039] The service module 2 and the vertical segments 4 were already provided with appropriate door 7 and window 8 openings during the process of production.

[040] The assembly of the building shown in Fig. 2, completes after attaching the last horizontal segment 3 and closing the construction with the vertical segment 4. The final step of constructing the building comprises constructing roof, finishing, painting, etc.

[041] The drawings Fig. 3, 4 and 6 present other embodiments of the transportable modular building according to the invention. Reference numerals of elements having the same functions remain the same as above, however to better clarify the assembly process, in some places they are complemented with lowercase suffixes.

[042] Fig. 3 shows already constructed and finished modular building 1, being a single family house. In this embodiment, two service modules 2a and 2b were employed. The service module 2a serves as a kitchen, whereas the module 2b is a bathroom of the building. In this case, eight horizontal segments 3a, constituting the floor of the building, and eight horizontal segments 3b, constituting the roof of the building, were used. The horizontal segments are attached to the service modules 2a and 2b, respectively on the level of the floor and the ceiling of the service modules. Eight vertical segments 4 were attached to the external side surfaces of the horizontal segments 3a, 3b, like in the preceding embodiment (Fig. 2). The horizontal segments 3a, 3b were attached perpendicular to the longitudinal axis of the service modules 2a, 2b.

[043] The thickness of the horizontal and vertical segments of this embodiment amounts to 0.2 m. Therefore all the building components occupies the area corresponding to four 20 ft containers, where two of them are formed by a service modules 2a and 2b and the other two by two blocks, each of twelve horizontal/vertical segments stacked vertically (cf. Fig. 1).

[044] Yet another embodiment of the modular building 1 according to the present invention in the form of two-storeyed terrace house is shown in Fig. 4. Each building segment 1 comprises two service modules 2c and 2d, placed parallel one on another, four horizontal segments 3a forming the building floor, four horizontal segments 3b forming the ceiling of the first level and the floor of the second level, four horizontal segments 3c forming the roof of the second level and twelve vertical segments 4 forming the walls of the building 1 and attached to the external side surfaces of the horizontal segments 3a, 3b and 3c. After the transportation of the building elements and the assembling thereof on the building parcel, the building was provided with balconies 9 and the roof 10.

[045] As in preceding embodiment, the thickness of the horizontal/vertical segments amounts to 0.2 m, thus all the components of each building segment 1 may be easily loaded on two vehicles adapted to transport a 40 ft container.

[046] Fig. 5 shows an embodiment of the horizontal segment 3 having a wooden frame construction. The main structural elements of this segment are two outer OSB plates 11 and the skeleton comprising five longitudinal beams 12, between which a number of transverse beams 13 are placed. The longitudinal beams as well as the transverse beams are made of pine wood in the class K27 (Polish norm PN-81/B-03150.01). The spaces between the longitudinal beams 12 and the transverse beams 13 are filled with the blocks 14 of rock wool. Steel connectors 15 shown schematically in the corners of the segment and in the half of its length allow connecting the segments together and/or to the service module.

[047] The steel connectors may be provided e.g. with threads for external screws, bolts blocked in corresponding openings, etc. or may simply constitute a welding points.

[048] Fig. 6 shows schematically yet another embodiment of transportable modular building 1 during the assembly process. The building shall constitute a two-storeyed small office. Buildings of this type are often used as provisional offices for the construction sites (e.g. during a motorway construction), where the building needs to be frequently decomposed and transported to another location. For this reason the service modules 2e are already provided with electrical and water supply systems (not shown) and with typical office furniture, e.g. desks, chairs or wardrobes. Moreover the horizontal and vertical segments as well as the service modules 2e are provided with doors 7 and windows 8 openings.

[049] The width of each service module 2e amounts to 2.3 m, its external height H amounts to 2.75 m, its internal height h amounts to 2.5 m, and its length L is slightly more than two times greater than external height and amounts to 6 m. As the service modules are open from the top, the horizontal beams 16 ensure its suitable rigidity during transport.

[050] The horizontal 3a, 3b and the vertical 4a, 4b segments have substantially the same construction and dimensions: the width (the height) corresponds to the internal height h of the service module 2e (2.5 m), and its length corresponds to the length L of the service module (6 m).

[051] After attaching the bottom service modules 2e by means of a crane on the building foundation and connecting them in end to end aligned relation together, five floor horizontal segments 3a were subsequently attached on the foundation and to the floor plates of the corresponding service modules 2e perpendicular to their common longitudinal axis. The central floor segment 3a' overlaps the adjoining service modules, providing greater stiffness of the modular building 1. Two vertical segments 4a were subsequently attached perpendicular to the horizontal segments of the floor and another vertical segment 4b was attached parallel to the longitudinal axis of the service module. Each service module is closed by a vertical segment 19 having the width of 2.3 m and height 2.75 m.

[052] Another service module 2f forms a part of the second level of the building 1, thus the bottom plate thereof is at the same time the top plate (ceiling) of the bottom service module 2e. The ceiling of the first and the floor of the second level of the building 1 shall be formed by another set of horizontal segments 3b, of which only one was shown, subsequently attached to the vertical segments 4a and 4b and to the bottom plate of the service module 2f. Additional reinforcement of the construction of the building is achieved by appropriate design of its segments, so as the columns 20 of the vertical segments 4 match the beams 21 of the horizontal segments 3. The horizontal segment 3c closes the top of the service module 2f creating a roof of the building.

[053] The components of the building are joined together by coupling connections 17 and coupling bolts 18.

[054] The building shown in Fig. 6 comprises seventeen horizontal segments 3 and eight vertical segments 4, therefore it occupies the area of three 40 ft containers. To facilitate transport and assembling of the building the corners of the service modules are provided with container anchors 22.

[055] It is obvious that above described embodiments of the invention should not be considered as limiting the possibilities of mutual configuration of corresponding elements of the modular building according to the present invention, as well as the types of construction of service modules and particular segments.